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Goals, results and prospects

J. C. Dao, D. Buestel, A. Gerard, C. Halary and J. C. Cochard

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DAO J C*, BUESTEL D*, GERARD A***, HALARY C***

and COCHARD J C*

*IFREMER - [Oceanological research centre], BP 337-29273

Brest Cedex - France

**CLPM (Comité local des pêches maritimes) [Local

committee on maritime fisheries], 17 rue Marie Le Bris,

29200 Brest - France

***EEC - Place du Général de Gaulle - 22000 St Brieuc

France

Original Title: Le programme de repeuplement de coquille St Jacques: finalité, résultats et perspectives.

SCALLOP (Pecten maximus) RESTOCKING PROGRAM IN FRANCE GOALS, RESULTS AND PROSPECTS

ABSTRACT

Since 1973, a great deal of research has been conducted into the natural resource management and extensive aquaculture of scallops (Pecten maximus). The findings over the first ten years made it possible to develop and implement a five-year program (1983-1987) involving restocking demonstration activities in Brest harbour and new management techniques in St Brieuc bay.

This paper presents the technical findings concerning resource management techniques and aquacultural operations. These findings have made it possible to stablize annual production for the St Brieuc scallop bed and to forecast a new seed biomass of 80-100 tonnes annually.

It is not yet possible, however, to implement all the new techniques identified, given various human considerations. The major economic, social and legal constraints involved are discussed in this paper.

I - G O A L S

The concept of restocking a species in a marine environment was first developed in France in the 19th century. Since then, all restocking efforts have been accompanied by heated debate and in 1979 a symposium was held on the subject at the IFREMER centre in Brest. So far, no restocking program in France has been truly successful, and the question remains: Is it possible, in the French context, to develop a model? Two types of research provide the answers: the first examines the mechanisms for natural resource renewal; the second, which is more experimental, consists in seeding animals in a given marine site.

There are four steps involved in the latter approach:

1. Obtain a supply of animals of the species selected, usually juveniles;

2. From this supply, reconstitute an adequate, fertile biomass;

3. Obtain, through natural reproduction, an abundance of larvae and juveniles;

4. Achieve an adequate level of recruitment to ensure renewal of the species while at the same time allowing fishing activities to be carried out.

Nothing in these operations should constitute a major hindrance that could jeopardize the demonstration. This condition is extremely restrictive, inasmuch as there is still too little known about the biology and zootechnics of marine species and the balances that exist between the animal and its environment. Lastly, once the experiments have been completed, a restocking program will be developed only if it is advantageous in socio-economic terms.

These constraints are the reason that any pilot program for restocking scallops must meet certain criteria before experts, management or researchers will assume the risk and before research teams will be hired for a project or work tools obtained.

The biotechnical criteria are as follows:

- there must be an available supply of animals large enough for release;

- it must be possible to make evaluations and take measurements at the various stages: survival rate, rate of growth, stock biomass;

- the site must be appropriate, with little impact from adjacent areas.

From a socio-economic standpoint, the criteria are:

- there must be encouraging reports on similar experiments in other places for the same or related species;

- scallop fishing must be an important socio-economic activity;

- the possibility of implementing the program in other areas at a later date must exist;

- investments must be feasible and consistent with investments in other projects, in terms of both personnel and financial resources;

- the program must have the support of potential users.

The scallop fishery in Brittany met all of these criteria: the sites were quite separate, harvesting was organized, very promising experiments were under way, and there was a convincing example involving the Japanese species. More than 700 vessels engage in scallop fishing, as either a main or a secondary activity, with a production of approximately 10,000 tonnes. Fishing areas are shown in Figure 1. Approximately 50% of Brittany's scallop production is provided by 400 small fishing units. It was therefore possible in 1982 to present a five-year program[1] with the following objectives:

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[1] Groupe de support général à la gestion des stocks, 1982 [stock management general support group]: five-year scallop program - 1983-1987.

1 - Support current harvesting by identifying the most appropriate natural resource management techniques;

2 - Seek to reverse the trend in evidence since 1976, that is, smaller catches, by focussing on the development of scallop beds through restocking activities involving juveniles.

The implementation programs were consolidated with the common goal of restoring the productive capacity of the scallop beds. The terms of reference were as follows:[2]

- Reconstitute a 500-tonne seed stock in Brest harbour capable of sustaining spat collection for the purpose of restocking other scallop beds at a later date.

- Develop new fishing methods in St Brieuc bay based on techniques used in seeded areas.

Actual restocking involved Brest harbour, the site of a scallop bed that had been depleted since 1963 (Figure 2). The proposal to reconstitute a seed stock was the subject of long debate centred on the following question: In the absence of proof as to the validity of restocking, what was the minimum level of seed stock likely to bring about stock renewal? The answer had to be clear in order to be understood by all of the participants (researchers, experts and management) and unequivocal so that, at the end of the project, it would be possible to determine whether or not the objectives had been.

Brest harbour was selected, mainly because of its morphology: it was an area that was geographically isolated and small in size. This meant that from a very few animals, a relatively large seed stock could be established. The figure of 500 tonnes was an estimate based on subjective evaluations as to the condition of the Brest stock before it had disappeared, the condition of stocks in which

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[2] Government plan contract - Brittany area, 1984.

proper natural reproduction had been observed (St Brieuc bay prior to 1978, Mulroy Bay, Ireland, between 1979 and 1981, Scotland between 1976 and 1984) and favourable information about other species (the black scallop, Chlamys varia, in Brest harbour and the Japanese scallop Patinopecten yessoensis). The figure is problematical, however, inasmuch as it cannot be stated positively, with regard to this species, that natural production of juveniles depends on the size of the parent stock, or that the figure of 500 tonnes, with the seed placed in a single high-density area, will be a determining factor in the 1988-1990 period.

It was not possible to obtain data on current or future harvesting in Brest harbour because the stock had disappeared. Attempts were made to identify the parameters of population dynamics in St Brieuc bay where there are still more than 300 vessels operating in a fishery that has gradually become more organized: the professional organization has established a set of regulations governing access to the resource, the licensing of fishing gear, annual quotas on volume and actual fishing time, and supplementary measures to adjust production to market demand. Experiments involving spat rearing and releases were conducted in both sites using similar methods; hence, the results obtained are comparable. These experiments, therefore, can serve as references in monitoring and understanding the development of the scallop population in Brest harbour.

At the socio-economic level, since 1975-1978 there had been general agreement about renewing Brittany's scallop beds by releasing juveniles. This was because of successful initial attempts at spat collection (BUESTEL, 1979), a successful experimental seeding of a batch of 25mm to 30mm juveniles (BUESTEL and DAO, 1979) and encouraging first attempts at acquaculture (BUESTEL et al, 1982, 1983). Two local teams were established, in Brest and St Brieuc, to provide on-site liaison between IFREMER and the experts. The decision to undertake the five-year program in late 1982 therefore gave formal recognition to the existence of a group of a dozen biologists and technicians. Investment was limited to the construction of facilities to streamline the rearing methods that had been developed. These methods, incidentally, continue to evolve.

II - R E S U L T S

Origin of scallops used for restocking

The demonstration of the effectiveness of seeding with juveniles collected in 1976 in St Brieuc bay indicated that 30mm was a good size for seeding purposes (BUESTEL and DAO, 1979). In 1982, the only sources of supply of juveniles were Ireland and Scotland, where collection was being introduced with favourable results (Table 1).

Although the importation of juveniles got off to a good start in 1982, few or none have been imported since that time (Ireland has stopped collection activities and Scotland has had technical problems with pre-rearing). These imported juveniles nevertheless demonstrated that by using the "suspended culture method", it was possible to rear large batches of juveniles with a moderate rate of mortality (30%).

Comparatively speaking, hatchery production, which has gradually recruited most of the staff members assigned to the national program, has been much more reliable and, since 1983, has become predominant. Thus, there has been a shift from a restocking program based on releases of imported juveniles to a program revolving around the artificial production of juveniles (Table 2).

The seed stock used comes from Brest harbour, where the adults are fertile most of the year. This has the following advantages: spawn can be deposited almost year round; the roe gives the animal considerably more commercial value; and the local stock is maintained and developed.

2.2 - Supply of juveniles

The first supply plan depended on the scallop's reproductive period. France, Ireland and Scotland all set up spat collectors during the summer, with sorting taking place in the fall. With this method, the juveniles are allowed to develop until they are large enough to be seeded, betwen May and July of the

following year (pre-growout). Juveniles can be transferred from the collection site to where they are seeded, either when the spat on the collectors are sorted in the fall, or in the early spring.

The second plan, which uses hatcheries, provides a more reliable supply of juveniles (Fig 3). Production currently centres on two periods: November to January and April to July (COCHARD, 1985). These periods could be extended so that juveniles could be produced year round. The nursery uses sea water that has been allowed to settle and had everything but the nutrients filtered out. Production of juveniles still depends on the quality of the environment; production cycles are slow in winter and rapid in summer, with a mortality rate that is exceptionally high (GERARD, 1985). Pre-rearing is even more dependent on the environment. Growth in winter is minimal; in summer juveniles are extremely susceptible to outside agents: predators (polydora, starfish and crab) that attack them at the larval stage; impurities that clog the mesh; and "red tide" (BUESTEL et al, 1985).

More than a million juveniles to be used for seeding were obtained from the production sequence (Table 3).

Improved yields were due to the various installations that were gradually introduced between 1983 and 1984 and to better control of rearing techniques.

2.3 - Survival and development

It is usually very difficult to estimate the development of juvenile releases for most species. The scallop's sedentary behaviour made it possible to determine growth and mortality rates since individuals could be identified with reference to a rope grid placed permanently on the seeded bottom. This method was unwieldly, however, and was very vulnerable to changes or disturbances to the grid over the three to five years the scallops were under observation (BUESTEL and DAO, 1979). Results are shown in Table 4.

Spat reach commercial size (86 mm in height) at the beginning of the third winter, or at the age of approximately 30 months. The survival rate is between 40% and 50% and, because of losses to predators, depends on the size of the juveniles released (Table 5). No difference in survival rates between the various batches of juveniles was noted in Brest harbour.

2.4 Affect of the restocking site

Monitoring of the scallop beds in Brest harbour and St Brieuc bay and the experiments in progress in these locations give clues as to the importance of the marine site to restocking operations. The data available indicates a different environment (there are no starfish or polydora in St Brieuc bay and the nature of the ocean bottom justifies releases of smaller juveniles).

Table 6 shows the differences in rates of growth, maturation and survival of the transplanted populations compared with those of the populations in the seeded sites.

The specific reasons for these differences are not clearly identified. There may be a genetic tie-in (DAO et al, 1985).

2.5 Methods for determining the success of restocking

Once the parent population has been renewed, it must be demonstrated that the parent stock will be replaced by the animals it has produced.

There are different investigative techniques available to determine how successful restocking is at the various stages of the biological cycle (BUESTEL, DAO et al, 1976).

- during maturation and spawning - by monitoring the gonado-somatic index;
- at the larval stage - by taking a sample of plankton;
- at the postlarval stage - by collecting spat from collectors placed in a natural environment;
- at the juvenile stage: measurement by divers at the scallop bed site.

In the case of Brest harbour, the stock has been depleted since 1963 and it is not certain whether environmental conditions are still such that juveniles will be able to thrive on the old scallop bed. The bottoms will probably have to be developed before the old scallop-fishing areas can be restocked.

This is why there will be more interest in the initial phases of the cycle, particularly the use of spat collectors. This technique has been used since 1973 to ascertain how successful the St Brieuc stock has been in reproducing in a natural environment (BUSETEL, DAO et al, 1978), and to determine the level of recruitment two years later (BUESTEL, DAO et al, 1979; BOUCHER, 1985). According to the observation network set up, so far no scallop spat have been collected in Brest harbour (an average of less than one scallop per collector). It will therefore be possible to show that restocking is successful if there is a direct relationship between increases in spat yields and the renewal of adult stock in the seeded area.

2.6 - Techniques for harvesting scallops

Drags are used to harvest scallops. This technique is very selective and the drag is able to collect 30% to 80% of the animals present with every sweep (BUSETEL, 1985). The mortality rate associated with dragging is considered to be very low but could be significant with certain types of vessel or particular fishing conditions (dragging speed, roughness of the sea, weight of the drag and length of teeth). From the yields observed, the drag appears to perform well, making scalloping so profitable that stocks are overfished.

This is why the experts have been forced to look into increasingly complex resource management methods: the high profitability of scallop fishing has caused an influx of foreign vessels and the creation of new units.

Since 1973, a special licence has been required in order to gain access to the scallop fishery. This licence limits the size of authorized vessels and the number of new fishermen allowed access to the resource. It prescribes the number and type of fishing drags to be used and the dates and times when scalloping is permitted. The latter measure, which arose out of a need to find a better way to adjust to market conditions, now makes it possible to set a total fishing quota, based on an estimate of available resources.

In 1978, a 3,500-hectare section of ocean was declared off-limits for a period of one year in response to a proposal by biologists, with a view to protecting a sensitive area and improving fishing the following year. This

restriction was complied with, at the cost of close surveillance, and produced the expected results. The experiment has increased interest in scallop resource management and rotational harvesting of fishing areas, although the experts still feel that it will be difficult to implement.

III - P R O S P E C T S

From the results obtained, it can be concluded that various basic restocking operations are technically feasible: larval and postlarval production, pre-rearing, bottom seeding and harvesting of the adult animals. Current experiments are still too recent to measure their impact on scallop stocks, however.

Nevertheless, a brief description can be given of the main activities and their expected results, and conclusions can be drawn regarding long-term prospects for the current program (Figure 4).

The key to development is to obtain spat that are cheap and plentiful. This was why the program in Brest harbour was implemented. The program consists in producing stock in an artificial environment, with a view to renewing natural reproduction. The larvae produced should give rise to the collection of spat from collectors, the only technique known that can provide the large number of juveniles needed for developing France's scallop resources. Spat collection is not all that can be expected from the program, however. There are other, less ambitious, possibilities.

Case #1: No effect

The possibility of the program failing must be considered. Failure may be due to an error in preparing the original project brief, such as an inaccurate estimate in defining the objectives, or to the presence of artifacts while the work is in progress.

If the project does fail, there will have to be an analysis by the participating teams and a report, which will be of major importance to any resumption of the project.

Case #2: Satisfactory development of animals but no effect on reproduction

This stage has been reached. As a matter of fact, survival and growth rates in the marine sites at Brest and St Brieuc are considered satisfactory. Progress made in the artificial production sequence is spectacular and although it has not yet been proven that extensive aquaculture is profitable, there is reason to believe that it will be within a few years. It is therefore quite easy to envision direct harvesting of animals seeded on the bottom. The restricting factor then becomes the small number of hatchery-reared juveniles available, which makes only limited development possible.

One technique involves high-density seeding over small areas. This technique is of interest to breeders who have beds in deep water. It still has only marginal impact on the environment because of the small numbers of spat involved.

A second technique consists in developing small stocks to which juveniles are added as a supplement to natural production. Increased densities on the bottom improve yields without appreciably increasing conventional fishing costs. This method has the advantage of being similar to current fishing methods but presupposes the existence of a co-operative organization capable of planning ways to harvest and control access to the resource.

Case #3: Positive effect on reproduction in a natural environment (restocking)

The release of juveniles creates or renews a seed stock: the larvae that are present after spawning occurs develop normally, leading to natural spat settlement. The spat develop on the bed and fortify the seed stock, which perpetuates the restocking effect. A small percentage of the animals may be fished.

Development by restocking therefore entails a prior investment in juveniles, followed by rigorous resource management. French fishermen are keenly

interested in using this model for their stocks and it is the prime objective of France's scallop development program.

Case #4: Positive effect on reproduction in a natural environment (spat collection)

Restocking can also expand into another kind of development: mass production of spat by natural collection from suitable collectors. This was achieved with a related species (in Japan).

In the case of experiments conducted on the scallop Pecten maximus, it is estimated that a minimum of approximately 100 to 200 juveniles per collector is required in order for collection to be commercially worthwhile.

Case #5: Positive effect on collection and restocking

This is the most optimistic hypothesis of the program. The activities initiated in 1983 are leading to successful use of extensive aquaculture techniques for the renewal of natural resources and the development of France's coastal areas.

IV - C O N C L U S I O N S

Spat collection is of crucial importance to the future of scallop breeding. It is a technique that is feasible on a large scale and opens the door to all kinds of extensive aquacultural developments. With inexpensive juveniles, medium-density seeded areas can be provided and harvested, once programs have been developed to optimize economic aspects (quantities, fishing times, quality, compatibility with other activities, and so on). Foreseeable developments therefore involve scallop fishing, scallop breeding and a new activity: the collection and sale of juveniles. The latter activity may prove to be of major importance in areas where it is difficult for scallops to become established because the ocean bottom is unsuited to spontaneous development (absence of settlements, loss of juveniles and/or adults to predators, and so on).

Not only must extensive aquacultural practices be technically feasible in the case of scallops, there must also be improved methods for harvesting these resources. Scallop fishermen with deep-water concessions can be expected to harvest them as profitably as possible. However, in public waters, whatever progress is made must be through an organized professional group able to manage the activities undertaken and orient production toward the most profitable methods. This should make it possible, among other things, to integrate other competing or complementary fishing activities.

These few reservations do not relate exclusively to socio-economic aspects. It should also be recognized that little is known about the kind of ecological environment conducive to scallop development.

There is a growing awareness of the significance of this factor, in view of the mortality and growth rates observed when scallops are reared in a natural environment. During the suspended culture phase (collection, pre-growout), a number of predators and competing species have been identified that either impede operations (cleaning of the structures) or suddenly make part or all of the marine site unusable (infestations of boring worms or the rapid multiplication of dinoflagellates). On the site bottom, there are the same constraints, particularly from predators such as various species of crabs, predatory snails and starfish. The mortality rate from these predators can be very high in unsuitable sites.

At the moment, the experimental methods being used to develop suitable new sites are proving to be lengthy and onerous. In Brest harbour, for example, five or six operations were required in four sites in order to limit mortality. Therefore, because of ecological constraints, the extension of restocking operations will probably be slow.

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LOCATION OF FRANCE'S SCALLOP BEDS (Pecten maximus)

(*Pecten maximus*)

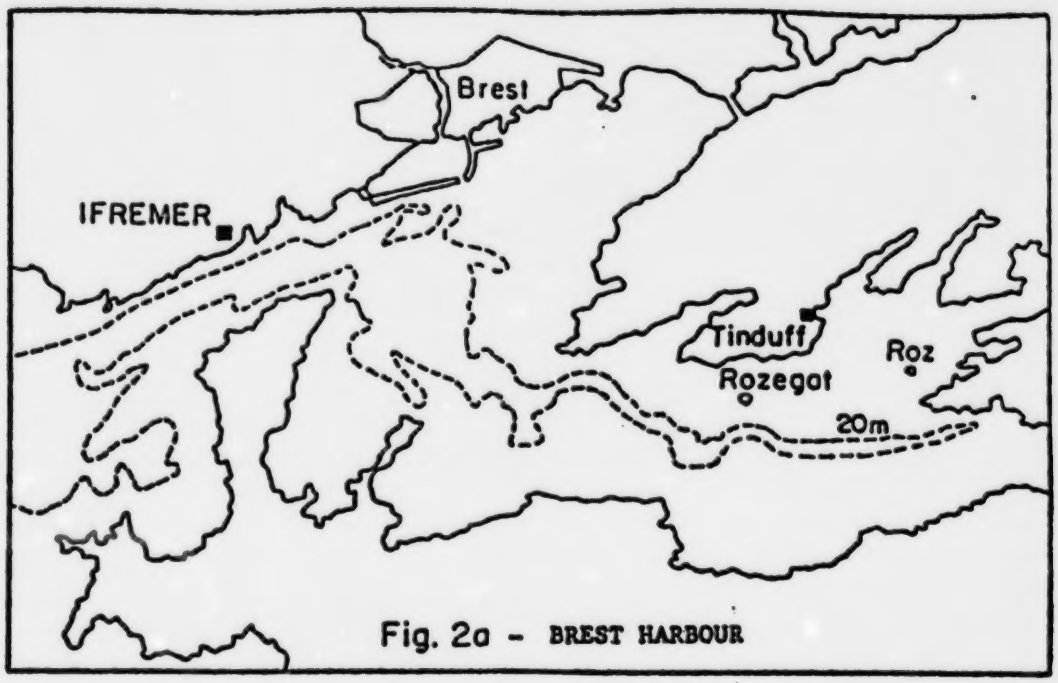

Fig. 2a - BREST HARBOUR

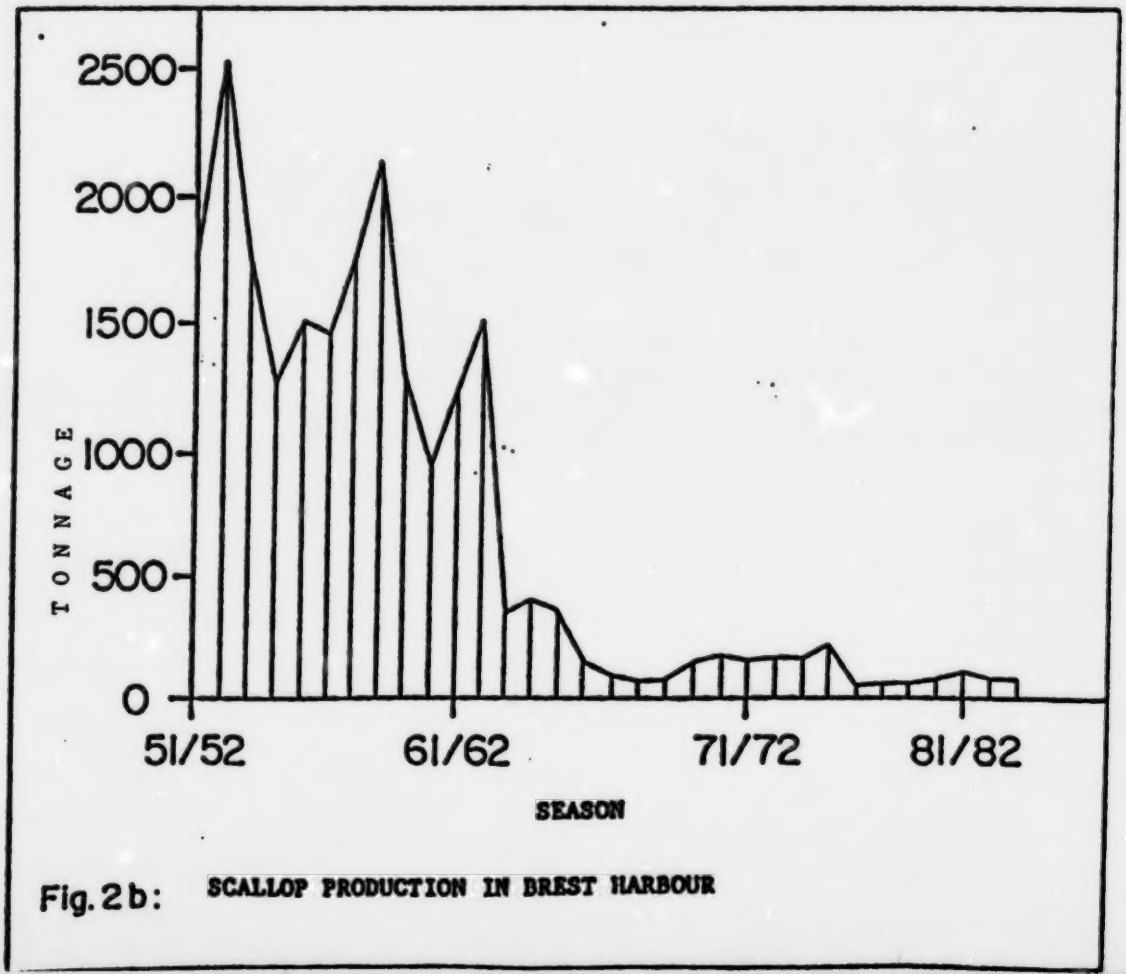

Fig. 2b: SCALLOP PRODUCTION IN BREST HARBOUR

	Ireland	Scotland	St. Brieuc	Brest
1979	super-abundance	a few hundred	1 to 55	0
1980	2 000	"	1 to 5	0
1981	1 500	"	5 to100	0
1982	200	"	1 to120	0

Table 1 - Catch Yield by Collector

	No of Spat from Collectors			No of Spat from Hatcheries	
Year	St Brieuc	Ireland	Scotland	Brest	SATMAR
1976	150 000	-	-	-	-
1980	-	-	20 000	1 500	x
1981	-	500 000		10 000	x
1982	-	300 000		80 000	x
1983	-	-	"0"	250 000	-
1984	-	-	"0"	800 000	110 000
1985	-	-	"500 000"	"1 000 000"	-

Table 2 - Juveniles Available for Restocking

	Hatchery	Nursery	Pre-rearing 1	Pre-rearing 2
1983	18 000 000	1 500 000	410 000	250 000
1984	23 000 000	2 600 000	1 200 000	800 000
1985	46 000 000	6 800 000		

Table 3 - Spat Production in Brest Harbour

Date	Origin of Batch	Characteristics	first winter	second winter	third winter	fourth winter	fifth winter
1977	St Brieuc	height (mm)	26	72	90	98	103
		weight (g)		60-64	125	148-162	188-202
		survival rate (%)	100		50	45	"40"
1980	Scotland	height (mm)	36	74	91	98	106
		weight (g)		66	116-123	141-158	174-192
		survival rate (%)	100		60	46	
1982	Ireland	height (mm)	27	65	90	97	
		weight (g)		47	110	144	
		survival rate (%)	100				
1981	hatchery	height (mm)	27	70	90	100	
		weight (g)		70	130	182	
		survival rate (%)					
1982	hatchery	height (mm)	27-30	65	88		
		weight (g)		50	130		
		survival rate (%)					
1983	hatchery	survival rate (%)	100	"60"			

Table 4 - Juvenile Releases in Brest Harbour

Size When Seeded (Hmm)	% Recovered	Size When Recovered (Hmm)
15	0	-
21	4	61
25	54	62
29	56	65

Table 5 - Impact of Juvenile Size on Seedings in Brest Harbour

Origin of Spat \ Area	Growth Rate		Rate of Maturation		Survival Rate	
	BREST	ST BRIEUC	BREST	ST BRIEUC	BREST	ST BRIEUC
IRELAND	=	<	≠	≠	=	<
SCOTLAND	=	=	=	≠	=	=
BREST	=	=	≠	=		=

Table 6 - Development of Juveniles Seeded at the Two Sites
(= the same, ≠ different, < lower)

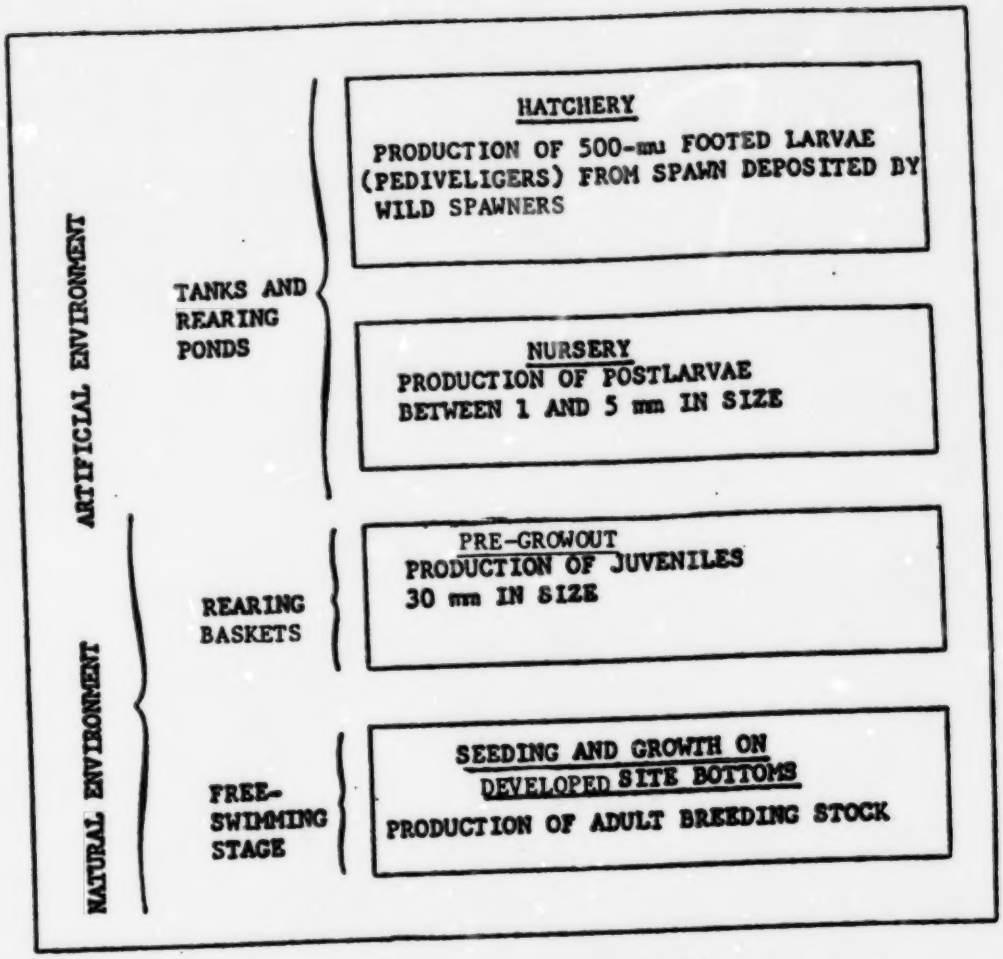
ARTIFICIAL ENVIRONMENT
NATURAL ENVIRONMENT
TANKS AND REARING PONDS
REARING BASKETS
FREE-SWIMMING STAGE
HATCHERY
PRODUCTION OF 500-µm FOOTED LARVAE (PEDIVELIGERS) FROM SPAWN DEPOSITED BY WILD SPAWNERS
NURSERY
PRODUCTION OF POSTLARVAE BETWEEN 1 AND 5 mm IN SIZE
PRE-GROWOUT
PRODUCTION OF JUVENILES 30 mm IN SIZE
SEEDING AND GROWTH ON DEVELOPED SITE BOTTOMS
PRODUCTION OF ADULT BREEDING STOCK

Fig. 3: PRODUCTION SEQUENCE - JUVENILES IN BREST HARBOUR

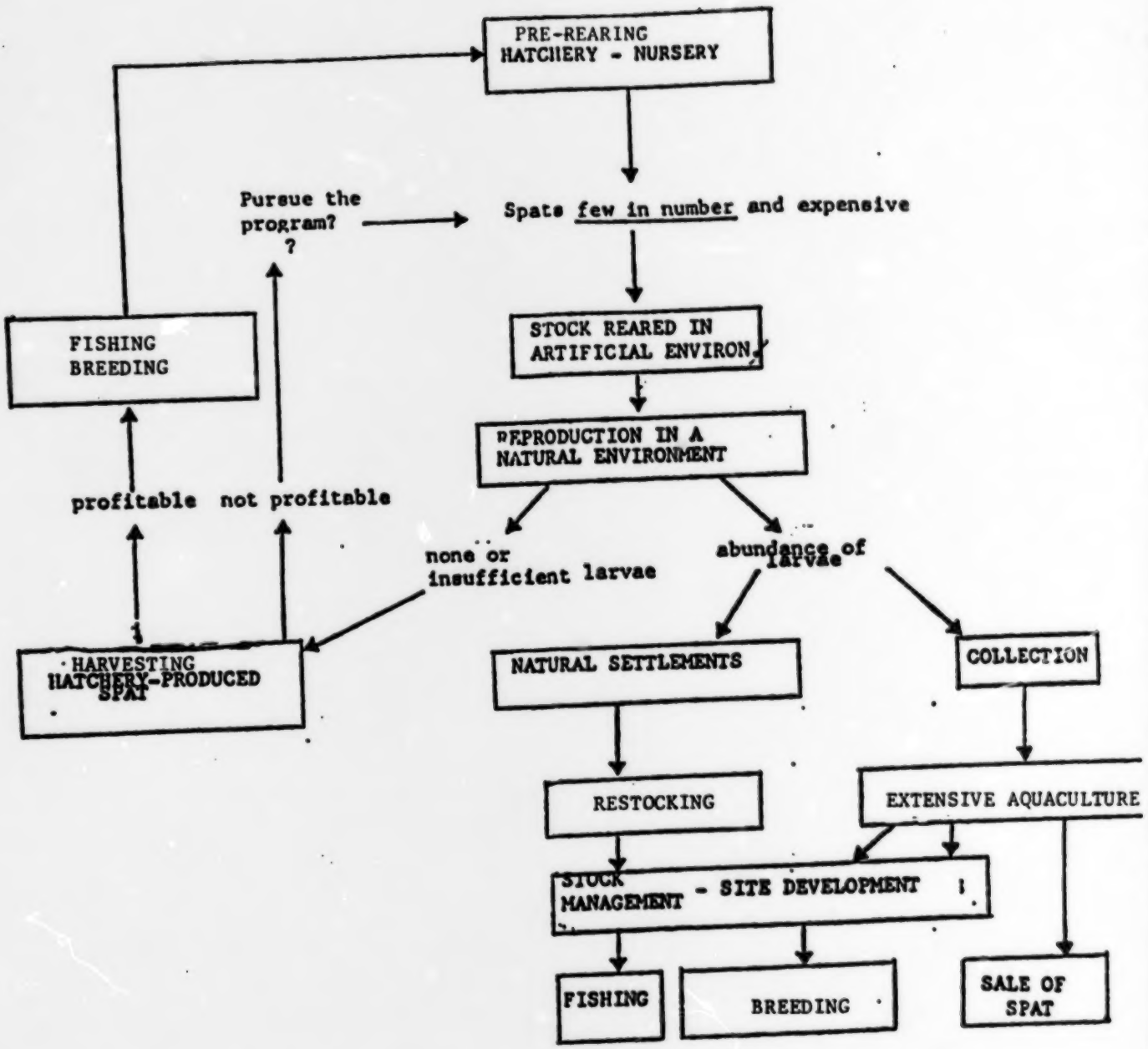

Fig. 4 : Prospects for the Scallop Program